Image analysis and classification applied to red soft-flesh peach ('Richlady') ripeness assessment

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Objectives

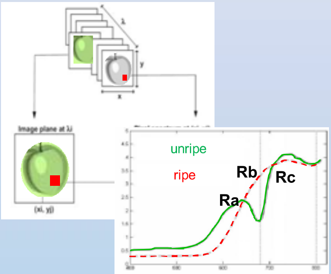
- To develop a new and improved procedure for classification of peaches based on computer vision for handling equipment, through
  - Optical characterization of peaches by spectrometry
  - Developing multispectral and hyper-spectral vision systems
  - To compare and validate the discrimination power of the different systems

Materials

'Red soft-flesh peaches at harvest and postharvest were measured during three seasons n =910 (**Minolta reflectance spectrometer, Duncan-Tech 3-CCD narrow band multispectral camera, HYSPEX VNIR (400-1000 nm,)**

4 days 10ºC + 3 days 20ºC

Methods



Ripening is closely related to the Chlorophyll absorption peak 680 nm

1. Optical measurements were locally taken centered on the equator of both sides to chracaterize fruits in a first phase

2. Multispectral images R_{680}/R_{800} of whole fruits

✓ Non supervised classification procedure based on histograms was performed.

✓ The classifications were compared with reference measurements such as Magness-Taylor firmness.

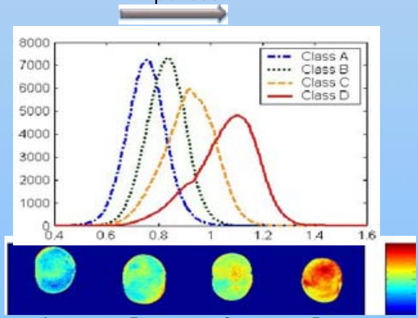
3. **Hyperspectral images** use the whole spectrum in each pixel (1-2 mm^2 per pixel) of the **whole fruit**

✓ Different algorithms combining three or more wavelengths around the chlorophyll region were used for discriminating ripeness levels. Raw spectra and images were pre-treated and/or combined in various indexes, with the aim to be compared regarding their discrimination power between ripeness stages.

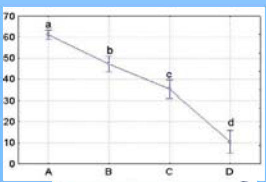
✓All indexes were compared with well-known indexes such I_{AD} (index of absorbance difference). The effect of convexity in the computed images was also eliminated.

Multispectral images-based classification

Ripeness

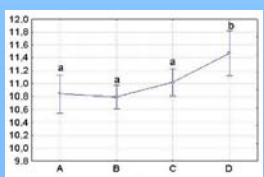


Magness-Taylor Firmness (N)



Ripeness

Soluble Solids (ºBrix)



Ripeness

✓**Multispectral imaging** is able to **classify** peach in ripeness classes according to handling **Magness-Taylor firmness (N) (MTF) thresholds**:

- ✓95% **Class D** include fruits with MTF<35N = high susceptibility to damages (80% MTF<18N, ready to eat).
- ✓85% **Class A** include fruits with MTF>53N. Needs ripening at selling point
- ✓**Classes B and C** show intermediate firmness and are appropriate for commercial handling

✓**Monitoring** from harvest to selling point:

- ✓Only 22% of fruits of class A at harvest evolved to classes C/D at the end of the ripening process.
- ✓91% of samples from class B at harvest evolved till class C or D.
- ✓83% of samples from class C evolved till class D, identified with very ripe fruits.

Hyperspectral images

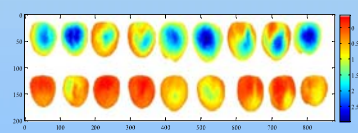
Reflectance images for each pair of fruits a) before b) after ripening

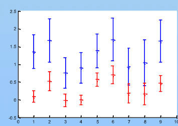
Ranges: mean ± STD within fruit before and after ripening

$Ind_1 = R_a + R_c - 2R_b$

a)

b)

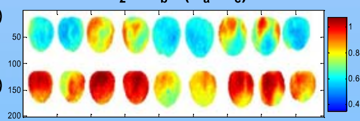


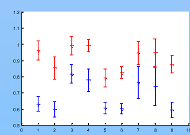


$Ind_2 = R_b / (R_a+R_c)$

a)

b)

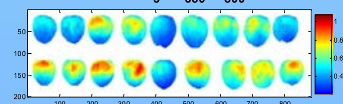


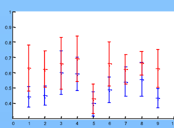


$Ind_3=R_{680}/R_{800}$

a)

b)

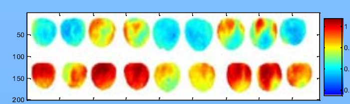


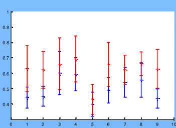


$I_{AD}= \log10(R_{720}/R_{670})$

a)

b)





✓Vertical blue and red lines (ranges) show parallel evolution.

✓Fruit specific effect: Original maturity determines final ripeness of every single fruit.

✓Differentiated ripening regions within fruits are observed. Some ripened regions, on the top, near the shoulders, are allocated in the same areas before and after ripening.

✓**Ind_2 presents the best performance in discriminating ripening.**

✓Indexes that combine R800 or R720 together with R680 (as Ind_3 or I_{AD}) show lower discriminating power than Ind_2 that only uses the (amplified) area of the chlorophyll band.

Conclusions

✓ Multi and hyperspectral imaging as well as equatorial optical spectral measurements, showed to be a promising tool to assess ripeness for red skin, melting flesh, early peach varieties.

✓This work proposes and validates a classification procedure for the assessment of peach ripeness into four categories based on multispectral imaging. Image based classes were related to MT firmness as the main current handling reference.

✓Hyperspectral image system is employed for searching the best combination of wavelengths regarding ripening sensing. Ind_2 shows the highest discrimination power for all the fruits because Ind_2 is a normalized index and it is focused on the shape at the chlorophyll absorption peak, at 680 nm. It can be implemented in a common spectral video camera, already installed in fruit handling lines.

✓Multispectral image classification can be used as a potential rejection criterion for problem fruits, as too soft or too unripe, showing high potential for supporting handling decision in fresh peach industries.

Acknowledgments

To Programa **TAGRALIA-** Comunidad de Madrid

To **ISAFRUIT EU**